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From Communities of Interest to Communities of Practice: The Role and Impact of Professional Development in Nuclear Security Education

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Abstract

In recent years, nuclear security has gained prominence on the international security agenda. Driven by post 9/11 anxieties and the politicization of fears regarding nuclear terrorism, concerns in this area have spawned a wealth of initiatives, which seek to counter this threat. Principal among these have been efforts to promote nuclear security education and infuse teaching and learning in this sphere with a more holistic understanding of subject, its relevance and its implications. Against this background, this article sets out the findings of empirical research into the impact of nuclear security 'train-the-trainer' professional development courses (PDCs) on the practice of an emerging cadre of nuclear security educators. In particular, the paper explores the value of this model as a means of establishing sustainable communities of practice in the context of nuclear security education.

Keywords: collaborative learning; community of practice; nuclear security education; professional development; train-the-trainer.

Introduction

In April 2010, President Obama hosted the inaugural Nuclear Security Summit in Washington, D.C. The summit was the first in a series of four biennial events, which marked the rise of nuclear security as a priority on the international security agenda.[1] Driven by post-9/11 anxieties regarding the potential for terrorist groups, such as Al–Qaeda and the so called Islamic State, to exploit the destructive potential of nuclear materials in a mass casualty attack (Mowatt-Larssen, 2010). President Obama highlighted the gravity of this issue in the opening plenary of the 2010 Nuclear Security Summit when he described nuclear terrorism as 'one of the greatest threats to global security' (Obama, 2010).

The need to protect materials and facilities and prevent accidents has long been a feature in a rapidly changing nuclear industry. In the early days of nuclear energy this was viewed largely as a national responsibility, with states - and in many cases nuclear operators responsible - for the development and implementation of nuclear safety and security measures (Findlay, 2017). However, growing recognition that a nuclear incident would likely be a serious trans-boundary event, combined with an increase in international nuclear trade precipitated the need for greater international

nuclear governance in this area. The international nuclear safety regime origins can be found in the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy, which formalized and outlined relevant responsibilities following a nuclear accident. Over the years, a number of forcing events, most notably the Chernobyl nuclear accident of 1986 led to ever greater levels of international collaboration and the sharing of best practice in this area. Nuclear safety culture has been a cornerstone of these efforts with poor human performance identified as a key-causal factor behind the nuclear accidents at Three Mile Island, Chernobyl and Fukushima (Tronea et al., 2014).

In contrast the international nuclear security regime remains relatively underdeveloped, consisting of a 'patchwork of formal and informal instruments' (Bowen et al., 2012). These can be traced back to the 1970s with the publication of international guidance by the International Atomic Energy Agency (IAEA) on physical protection of nuclear material, followed by the legally binding Convention on the Physical Protection of Nuclear Material (CPPNM) in force since 1987. However, the evolution of this framework has been relatively slow and sporadic in the absence of a major nuclear security incident (Bowen et al., 2016). States have also traditionally been reluctant to share information in this area due in part to a 'pre-existing culture of secrecy' when it comes to nuclear security issues (Bowen et al., 2014). Against this background the past six years have seen the international community devote considerable effort and resources to strengthening nuclear security and increasing international collaboration in this area. The approach has been necessarily wide-ranging and includes improved legal and regulatory frameworks, the elimination of sensitive materials, the introduction of new security technology and protocols, and an increased focus on contingency planning and response following an incident.

Underpinning this web of efforts is the concept of security culture and the growing recognition that the effectiveness of technical security measures and systems depends heavily on the individuals working within them, the relative importance they collectively place on nuclear security, and their knowledge and expertise in this area.[2] The influence of the human factor on security systems was all to clearly highlighted in 2012 in the United States when three elderly and unarmed anti-nuclear activists defeated multiple layers of security at the Y-12 National Security Complex in Tennessee (Schlosser, 2015). While this facility had spent hundreds of millions of dollars on high-tech security systems, these were poorly maintained and operated, with both the security and management teams systematically failing to follow standard operating procedures (Friedman, 2012). The importance of nuclear security culture was highlighted at the 2012, 2014 and 2016 Nuclear Security Summits. Here global leaders in attendance called for enhanced international collaboration in this area, emphasising the essential role of education (and training) in establishing a robust nuclear security culture from the early stages of a nuclear professionals career.

Security-related topics have traditionally either not featured or formed only a small part within the education of a nuclear professional. This is not least because the breadth of nuclear security as a subject area presents a unique challenge for educators.

A comprehensive approach requires academics to reach across disciplinary boundaries and engage with knowledge and concepts from the physical sciences, law, psychology and security studies, among others. For those situated in the disciplines of physics and engineering, for example, it is necessary to consider how amorphous concepts such as human reliability and culture effect the performance of security systems. Conversely, students hailing from the social sciences must be exposed to the physical properties of nuclear materials in order to understanding the limitations of security systems against the full spectrum of nuclear risks. As of 2010 there existed just a handful of academic programmes in nuclear security worldwide, none of them comprehensive in scope. This disparity also extends to security training within the nuclear industry. A recent report by the World Institute for Nuclear Security (WINS) identified some 230,000 current professionals with accountability for nuclear security worldwide, with existing courses having the capacity to train just over half of these individuals.

In attempting to address this gap, a number of international bodies, national governments and non-governmental organizations have sought to launch new training opportunities, while also supporting educational institutions, to establish new and sustainable programmes in this area.[3] By establishing a comprehensive nuclear security education system within a state, the next generation of nuclear professionals will be exposed to key issues during their formative years. This will help to foster an awareness and understanding of security issues, which they will take into their professional careers within the nuclear sector.

The dominant approach to promulgating nuclear security education to date has been through the medium of professional development courses (PDCs), with a 'train-the-trainer focus'. King's College London has been at the forefront of efforts by a number of universities to develop PDCs in nuclear security, with a focus on countries with nascent or developing nuclear programmes such as South Africa, Indonesia and Morocco. These courses aim to provide training to academic faculty working in disciplines that contribute to the human resource pool for employers in the nuclear sector. Early indications suggest that these PDCs and other initiatives to promote nuclear security education have been successful. At the 2015 Annual Meeting of the International Nuclear Security Education Network (INSEN), attended by 70 educational institutions from 37 member states, it was announced that 42 Network members had recently launched new programmes in this area.

Against this background, this article sets out the findings of empirical research into the role and impact of professional development for future nuclear security educators. In particular, the article explores the value of the PDC model in establishing what Lave and Wenger termed a 'community of practice' in the context of nuclear security education (Lave and Wenger 1991). How effective, for example, has the PDC approach been in facilitating the shift from communities of interest, where educators within a given nuclear community share little more than a passing awareness of nuclear security, to sustainable communities of practice characterised by a shared repertoire of resources, approaches and frameworks of action. The analysis draws on fieldwork conducted around a series of professional development

workshops organized for three regions, Sub-Saharan Africa, South East Asia and the Middle East and North Africa (MENA). This original data provides a unique insight into the evolution of nuclear security education in the regions concerned.

Nuclear Security, Collaborative Learning and the Community of Practice

In recent years, the relationship between education and security has been the subject of growing interest in academic circles. Perhaps not surprisingly, given the rise and consequences of Islamist-related terrorism, a good amount of the literature in this area has explored issues related to radicalization, particularly in terms of causal trends and the pathways to violent extremism. A recent study by Gambetta and Hertog, for example, gave robust empirical grounding to the link between aspects of vocational education, particularly engineering, and Islamist terrorism (Gambetta and Hertog, 2009). The work of Gambetta and Hertog builds on a broader body of scholarship that has "found evidence of a positive correlation between level of education and militancy both among Islamic and left-wing radicals" (202).

Yet this focus on the role of education in the causal equation of extremism, whether violent or non-violent, represents only one aspect of the academic debate. In this broad area of terrorism, there is another strand of literature that explores the role of education in preventing or countering extremism and otherwise strengthening security, as well as trends that have emerged around this theme. Gearon, for example, offers a useful insight into the "counter terrorist classroom" with a critique of the "use of religion in education for political and […] security purpose" (Gearon, 2013, 129). At a more practical level, Cozine's study of the extent to which game-based learning can enhance comprehension and support the development of critical thinking on terrorism and homeland security courses provides a good example of the diverse ways in which the academic community are trying to understand and engage with this fluid and rapidly-evolving relationship between education and security (Cozine, 2015, 367). Broadly speaking, it is to this preventative dimension of the education-security nexus that our research seeks to contribute, by adapting the concept of community of practice to the nuclear security context and using this as a means of exploring recent, innovative efforts to promote nuclear security education.

The ideas that underpin the concept of community of practice, namely 'the recognition of knowledge-based social structures and groupings of people who interact around their practices, with the aim of improving them', are not new (Blackmore, 2010, 103). Wenger points out, for example, that the concept has its roots in the attempts by scholars such as Bourdieu, Giddens and Foucault 'to develop accounts of the social nature of human learning inspired by anthropology and social theory' (Wenger, 2010, 179). The concept also draws on the systems theory tradition since, at a fundamental level, a community of practice 'can be viewed as a simple social system' (Ibid.). Yet it was only at the beginning of the 1990s that the term 'community of practice' (CoP) was coined by Jean Lave and Etienne Wenger and began to emerge as a conceptual focal point in the study of education and learning (Lave and Wenger 1991). In any case, the notion of 'community of practice' is now

one of the dominant conceptual approaches to thinking about social learning systems and the transformative processes that shape the evolution of these systems (Hung and Yuen, 2010).

So what are communities of practice? Fundamentally, the concept refers to groups of people who engage in a 'process of collective learning in a shared domain of human endeavour' (Wenger cited in le May, 2009, 30). Communities of practice are much more than mere networks of acquaintances or groups of colleagues. Indeed Wenger makes clear that 'membership is not just a matter of social category, declaring allegiance, belonging to an organization, having a title or having personal relations with some people' (Wenger, 1998, 74). Rather, they are interactive learning communities that actively engage in dialogue, exchange and the production of learning *as practice*. In this context, Wenger identifies three essential characteristics that underpin the fusion of community and practice: mutual engagement, a joint enterprise and a shared repertoire (73).

Mutual engagement refers to 'the way members engage with and respond to each others' actions and establish relationships based on this engagement' (Bolander Laksov, Mann and Dahlgren, 2008, 123). For as Wenger points out, 'practice does not exist in the abstract. It exists because people are engaged in actions whose meanings they negotiate with one another' (Wenger, 1998, 73). For example, a 2011 study of 'learning' by Hispanic youth in three US environmental after-school clubs, observed how different roles and responsibilities emerged from sustained interaction amongst peers (Aguilara and Krasny, 2011, 225-229). Determined through a combination of ability, commitment, attendance and other factors, group membership evolved to include leaders, organisers and a variety of task-specific roles, including translation.

Building on this, the idea of a joint enterprise refers to the manner in which members understand, identify with and commit to supporting the development of the community and its practice. A community of practice does not exist in a vacuum – these entities inevitably develop in broader historical, social, cultural and institutional contexts – yet the form of the community and the interpretation of its practice are, for the most part, negotiated by its members (Wenger, 1998, 80). Drawing again on the aforementioned study, mutual goals were first negotiated within peer groups, with input from relevant external actors (Aguilara and Krasny, 2011, 227). These were then clearly articulated, serving to shape activities carried out by the different groups.

The third characteristic, a shared repertoire, relates to the development of various resources over time, a product of the community's shared enterprise and effort. The repertoire of a community of practice includes 'routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions, or concepts that the community has produced or adopted in the course of its existence' (Wenger, 1998, 83). This ever-expanding repertoire charts the community's evolution through the activities of its members, while also forming the 'discourse by which members create meaningful statements' regarding the domain within which the community is situated (Ibid.).

It is our contention that prior to engaging in the PDC process, the majority of participants involved in this study formed what might be loosely termed a community

of interest. That is to say, these educators from a range of disciplinary and national backgrounds had individually encountered nuclear security as a concept, but had little understanding of its nature or how it might align with their own teaching practice. This was a theme that emerged clearly from our qualitative research. One participant summed the situation up well:

> 'I have been interested in the security aspect of the nuclear industry for many years. But the focus in my country has been limited to the physical protection of nuclear materials and I have not been able to engage with this in the context of my own teaching. Also, there has not been any real community around this subject. There are not many people to discuss this with! Certainly nobody has been discussing the human element of nuclear security…things like insider threats'.[4]

As the analysis below will demonstrate, this quotation was representative of the general sentiment across our sample group. Participants shared a general interest and curiosity with regard to nuclear security, yet limited exposure to and opportunities for engagement with the more holistic understanding of nuclear security that has emerged in recent years meant that these educators were little more than isolated members of a disparate, 'imagined' community of interest in the most vague sense.[5] In the following sections, we will draw on empirical evidence to argue that the nuclear security PDC process and other opportunities provided a framework within which the shared interest of participants could develop into something far more potent and substantial, namely a community of practice characterised by mutual engagement, a joint enterprise and a shared repertoire of resources. Furthermore, we will argue that the development of this nuclear security education community of practice has gained an irreversible momentum that will ensure its continuity in the medium- to long-term.

Nuclear Security Education: The Professional Development Model

In 2011, KCL established the first international PDC in nuclear security education in conjunction with the newly established International Nuclear Security Education Network (INSEN). This early PDC sought to capitalise on growing international interest in nuclear security, with the two-week course bringing together a diverse group of academics from a range of disciplines around the broad theme of nuclear security. The PDC provided an introduction to nuclear security, but sought to go beyond the simple exchange of information, instead aiming to combine substantive knowledge of nuclear security issues with teaching methods and pedagogical best practices. The ultimate goal here was to equip course participants with a better understanding of how learning in this area can best be encouraged and facilitated among students.[6]

The success of this initiative – the PDC was run multiple times in London between 2011 and 2014, providing support to over 60 educators from 17 countries – set the path for a broader initiative to establish a series of 'regional hubs' to provide

further opportunities for professional development in nuclear security education. Drawing on the mature processes and materials developed through the original PDC, as well as the expertise and knowledge of KCL academics and partners, this 'regional hubs' approach aims to provide support to regional partners seeking to develop their own nuclear security education PDCs in Sub-Saharan Africa, South East Asia and the Middle East and North Africa (MENA) regions. This initiative is innovative and ambitious in the sense that it seeks to foster self-sufficiency in lieu of dependency. Over the medium-term, the model aims to foster a sustainable nuclear security education architecture by transferring ownership of the PDC process to local institutions that will, over time, develop as regional focal points.

The first phase of this regional hubs approach was implemented for Sub-Saharan Africa, with the initial PDC held in South Africa in January 2014. Here, KCL partnered with the University of the Witwatersrand (WITS) to deliver five PDCs covering key aspects of nuclear security.[7] As before, the focus of these PDCs was on how different nuclear security topics could be incorporated into educational programmes (new or existing) at universities. A smaller number of participants responsible for developing training programmes at nuclear facilities and/or regulatory organisations were also selected. The goal here was to foster links and collaboration between academia and industry, with a view to developing a mutually beneficial relationship that would enhance the scope and impact of education in this new but practically-focused subject area. This bottom-up approach is in stark contrast with the forced, top-down approach that has traditionally characterized the US approach to homeland security. In his analysis of efforts to promote civil defence education in the United States in the 1950s and 1960s, for example, Preston describes in detail the manner in which the government "aggressively pursued the domestic security of its citizens through community, and national level, strategies" that were imposed on educators by executive order (Preston, 2015, 387).

Subsequent stages of the regional hubs model have seen KCL partner with universities in India, Indonesia and Morocco. In operational terms, each of the regionally focused PDCs follows the same basic structure initially developed and trialed in the United Kingdom. Each PDC comprises two one-week workshops of intense teaching and learning separated by a period of approximately one month. Over the course of these two weeks, participants are introduced to key substantive issues in nuclear security and, more importantly, provided with insights into how these issues might be incorporated into curricula. Sessions are highly interactive and courses include table-top exercises and simulations that seek to ground theory in practical situations. To consolidate and reinforce the learning outcomes of the PDC, participants are also asked to complete exercises in the period separating the instructor-led workshop weeks. These exercises revolve around curriculum design and development and seek to support participants in applying what they have learned to their own professional context.

Capturing the Impact of Professional Development in Nuclear Security Education

Given the ambitious agenda for education and training encompassed by the PDC approach outlined above, particularly the regional hubs model, it will come as no surprise that the process has absorbed considerable resources, both financial and intellectual. The range and ambitious scope of the education, training and other initiatives launched over the past few years have undoubtedly given new international momentum to nuclear security as an area of research, learning and practice. But what has been the nature of the impact here? What can we learn from the process? To what extent has the international enthusiasm for nuclear security education found form in the professional practice of educators and trainers in the countries concerned? In short, how successful has the drive to develop sustainable nuclear security education infrastructures been?

To date, there has been no large-scale and systematic study of the impact of nuclear security professional development on target audiences. Certainly, implementers regularly attempt to gauge the effectiveness and value of discrete workshops or events, usually through targeted feedback forms, with a view to assessing and refining content and delivery for future activities. Yet this event-specific feedback reveals little with regard to the impact of nuclear security professional development efforts more broadly and over time, nor is it intended to. Against this background and in parallel to the PDC process, the authors conducted empirical research over a two-year period with a view to capturing the impact of these activities. Let us be clear, the approach here was not intended to assess or evaluate security culture in the participants' countries of origin. Rather, our research focused on the professional practice of study participants and sought to do two things: First, to identify and outline the various ways in which insights regarding nuclear security issues, curriculum design, and teaching methods were applied by participants in their own professional practice. Second, to explore the extent to which the PDC process has contributed to the development of a nuclear security education infrastructure in the countries/regions under study.

The sample group for the research project was recruited from nine PDCs over a two- year period, January 2014 to December 2016, with all PDC participants eligible for inclusion in the study. Participation in the research project was voluntary and informed consent was sought from all participants.[8] In total, the sample group comprised 120 unique research subjects from 13 countries.[9] The research team adopted a mixed methods approach that combined surveys (pre-intervention and post-intervention), semi-structured interviews and focus groups. This primarily qualitative approach offered a means of exploring in detail participants' experience of the PDC process. In particular, the methodological approach allowed us to gain a comprehensive understanding of the various ways in which the knowledge and skills acquired by participants were integrated into educational practice. The emphasis on qualitative methods was also designed to allow for the bureaucratic idiosyncrasies that characterize the academic landscape in different national contexts. In total data was gathered from nine focus groups, over 50 semi-structured interviews, and some 250 questionnaires.

Major Research Findings

Four key themes emerged from analysis of the project data. These themes, described below, have important implications for broader effort to grow education and training programmes in this area in order to develop a robust nuclear security culture globally. Furthermore, these themes reveal much about the role played by the PDCs in facilitating a shift towards a sustainable community of practice in the area of nuclear security education.

1. *There is a strong consensus regarding the need for professional development in nuclear security education and training*

In many of the countries represented at the KCL PDCs, there are ambitious plans for civil nuclear expansion. In South Africa, for example, the 'Integrated Resource Plan for Electricity (IRP) 2010-2030', published by the Department of Energy sets out plans for six new 1600 MWe reactors by 2030. In India, the government has plans to increase the country's installed nuclear capacity from 5.7 GW to at least 10 GW by 2020 (Conca, 2016). Elsewhere, nuclear newcomers Indonesia and Vietnam, have longstanding plans to establish programmes in the 2020s in order to meet rapidly increasing energy needs. The above developments are just a few examples of current efforts to engage with nuclear power in the countries represented in this study. Beyond these large-scale projects, radiological sources used globally in hospitals, universities and industry must also be protected and form an important part of the nuclear security regime.

Clearly, the widespread use of radioactive sources combined with ambitious plans for nuclear expansion in certain countries has important implications in terms of the need for trained personnel in the nuclear sector. This is particularly true within the security context given that the threat posed by terrorist groups and non-state actors in many of the countries represented in this study is significant. From the deadly attacks perpetrated by Boko Haram in Nigeria, to the aggressive recruitment efforts of ISIS in Indonesia, to the destabilizing effects of the conflict in Ukraine, there is a pressing need to strengthen nuclear security culture (Institute for Policy Analysis of Conflict, 2014).

PDC participants were keen to highlight that their host organizations are aware of the future technical needs in this sector. For example, many of those interviewed referenced the plans for their universities to capitalize on nuclear expansion by increasing student numbers on established courses such as nuclear engineering, nuclear physics and radiation protection: 'We will see our nuclear engineering and nuclear physics programs expanding to meet the needs of industry'. The chain of supply and demand in this regard is clear: growth in the national nuclear sector will translate into job opportunities for trained nuclear specialists.

However, the emphasis placed on technical training and development (perceived to be significant areas of future growth) lies in stark contrast with the current dearth of educational courses that address nuclear security issues. Focus groups revealed a strong consensus regarding both the significance of the threat of

nuclear terrorism, and the need for professional development and training in the area of nuclear security. As one participant noted: 'There is not a lot of awareness around nuclear security. For many people this refers to guards and other physical protections [sic]. This idea of a nuclear security culture with a strong human dimension is a new one that we must learn about.'

Other participants went further in their views: 'It is very clear to me that nuclear security is an important subject and we must instill this view in the minds of our students. But this subject of nuclear security is new to many people and there must be training and education. What courses should be developed? How should these courses be developed? Otherwise we will be aware of a threat but we will not know how to deal with this threat'. This view was a common one, echoed by participants from most of the countries represented at the PDCs.

2. *Participants were keen to play an important role in determining how PDCs could best support their professional development needs*

From the outset, PDC participants were keen to stress that the conventional, conference-style transfer of information held little appeal in terms of their professional development as educators engaging with nuclear security. Participants were, for the most part, professional academics and were accustomed to acquiring and digesting new information, often in rapidly changing contexts. Therefore, while substantive knowledge regarding key issues in nuclear security was perceived to hold value, it was not the principal factor motivating participation in these nuclear security PDCs. As one participant noted: 'For me the issue is not new information. There are many ways of getting new information. For me, the question is how I can use information on nuclear security in my classes'.

In interviews and focus groups, PDC participants consistently emphasized their desire to increase their understanding of approaches and methods with regard to teaching nuclear security. In this context, participants proved eager to engage with practical exercises and simulations, discussions on curriculum design and the nexus between nuclear security and education/training. The enthusiasm of participants for interactive elements of the PDCs was represented clearly in pre- and post-workshop questionnaires. For example, over 90 per cent of participants indicated that the hypothetical facility that formed the basis of a table-top exercise used in many of the PDCs was 'very useful', with the same percentage indicating that this was something that they would seek to incorporate into their educational practice.[10] Case studies were also singled out during focus groups as particularly informative: 'Case studies bring the session to life and are far more exciting to listen to than standard lectures. Case studies are directly applicable to our teaching'.

This enthusiasm and feedback played an important role in shaping the structure and content of the PDCs. Organizers recognized that participants were well-placed to judge the type of support needed to develop their nuclear security education plans and the PDC design reflected this fact. From a developmental perspective, then, an ongoing objective of these activities was to provide participants with the

opportunity to engage with course content and work out how this content might best be integrated into their own educational efforts.

On the whole, the ongoing effort to capture and respond to participant feedback as part of the PDC design process resulted in a symbiotic and mutually beneficial relationship whereby the PDCs evolved according to participant needs. This approach holds lessons in terms of best practice regarding supporting curriculum design efforts. On a larger scale, however, the approach says much about the proactive role played by participants in moving from being members of a community of interest around nuclear security to members of a community of practice, discussed in greater detail below. In seeking to shape the support provided, participants engaged in a powerful and cumulative process of collective learning and development.

3. *Participants wish to have templates upon which to base their nuclear security education and training development efforts*

Closely linked to the point above, interviews with participants consistently revealed a strong demand for practical resources that could be used to support curriculum development in nuclear security education and training. This is not surprising, since the more holistic understanding of nuclear security that frames current thinking in this area is a relatively recent concept. As one Indonesian participant noted, 'Nuclear security as a discipline is not developed yet in our country and educators need materials like table-top exercises and case studies'.

As indicated above, table-top exercises and case studies were seen as particularly valuable resources by participants since these provide an interactive means of engaging students in nuclear security issues, 'I am very interested in the hypothetical scenario because this will give me something to work with. I can use parts of this or maybe even all of this to help students understand the points I am making'. Crucially, these approaches help to ground abstract discussions of nuclear security in real-life scenarios. As one participant noted: 'By giving such "real-life" examples close to home, hopefully the exercise would help students become aware of the significance and the relevance of nuclear security to their work'.

While important, the design and development of interactive resources such as these demands considerable time and effort. Moreover, those participants with no formal training in educational methods and practice can often find it challenging to develop practical exercises and activities that both engage students in the classroom and align with desired learning outcomes. These challenges were highlighted consistently throughout the research process. One participant summed up the broader view using the example of case studies, 'Case studies are extremely valuable resources…time is an issue for us and these bring together information and allow us to focus on how to use them in classes. The case studies session also shows us how to structure these resources so that they will be useful for students'.

Clearly, then, there is strong demand for practical resources to support education and training efforts. At the same time, it is important to note that participants were not seeking fully formed textbooks or presentations from which

whole classes on particular aspects of nuclear security could be mirrored directly. Rather, the demand here was for collaboratively developed and adaptable templates that could serve as a basis for further work. Participants were keen, for example, to shape materials around aspects and features of their own national and regional contexts: 'I want materials that I can make relevant to students in my country by adding some examples from domestic or regional contexts'.

In this sense, resources were viewed as the starting point for a design process that was unique to each educator and their organizational/national situation: 'It is important to have a starting point, some materials that can be adapted for different classes and courses. This helps to direct the efforts of teachers as they explore how to use this subject in their teaching'. This idea of resources as a starting point also speaks to another important issue: the risk of a progressive homogenization of ideas and approaches that would limit the intellectual scope of security-related thinking. Much of the resources provided to participants were exercise-based and designed in a manner that avoided pre-determined outcomes. Participants were encouraged to bring their own experience and knowledge, both past and newly acquired, to bear on the decision-making process. This intellectual freedom to explore different causal pathways appealed to participants and, combined with the breadth of national and cultural diversity among participants, ensured that assumptions were consistently being challenged by alternative perspectives. From a pedagogical perspective, this approach aligns with Feiman-Nemser's argument that 'serious and sustained teacher learning is a necessary condition for ambitious student learning' (Feiman-Nemser, 2012). On a larger scale, and similar to the previous sub-section, this approach also provides evidence of a broader shift towards an international community of practice around the theme of nuclear security.

4. *The plans of participants to incorporate nuclear security into their education and training are heavily dependent on perceived demand, resources and/or institutional support*

While the majority of participants are active in developing plans to integrate nuclear security into their education and training efforts, research revealed three significant obstacles to advancement: perceived demand, resources and institutional support. In terms of institutional demand, it is significant that prior exposure to security issues is not currently a requirement of employment in the nuclear sector, where such training is usually provided if deemed necessary on the job. This situation, combined with a relative lack of awareness regarding the importance of nuclear security in comparison with nuclear safety, means that there has been little incentive for nuclear security to be included in already crowded curricula in departments like physics and engineering. This point was emphasized by several PDC participants across different countries who have experienced at first hand the challenges of creating space within curricula for nuclear security. As one participant noted: 'There are many technical issues to be covered on the courses I teach. It is sometimes difficult to persuade the university that we need this subject of nuclear security'.

While safety is an intrinsic part of any technical course in science or engineering, little if any attention has traditionally been given to security. As such, scientists and engineers going into the nuclear sector typically engage with a strong pre-existing culture of safety, embedded during their studies, but little if any awareness of security issues. Without exposure during the formative years it will take much greater effort to establish a security culture within this group during their professional lives. However, there are indications this situation may change in the mid to long-term, with the nuclear industry increasingly recognizing the role that all personnel have to play in security and the need for demonstrable competency in this area through 'establishing appropriate standards for selection, training, and certification of staff' ("Joint Statement of the 2014 Nuclear Industry Summit, 2014). As industry starts to place greater onus on security awareness and knowledge for its personnel an educational market will start to emerge for technical and other graduates with competency in nuclear security.

With regard to resources, the conception, design and implementation of a new course - be it a training workshop, a single academic module or an entire graduate-level programme - requires significant investment in terms of staff time and teaching resources (classrooms, AV equipment, etc.). Even to incorporate aspects of nuclear security into existing courses requires considerable resources. As one participant noted: 'developing a new curriculum is something that demands a lot of time and energy. This is not something that can happen immediately, it must be carefully thought through and designed'.

However in many organizations in academia and industry alike, there is an acute shortage of resources. In all the countries under study, universities are competing for limited and often decreasing government funding while those within industry are ever vigilant for ways to cut expenditure and streamline resources. These factors, combined with often-harsh economic conditions mean that the ability of staff to propose and implement new courses is limited. In the academic sector, for example, this shortage of resources means that unless there is a clear and pressing demand, plans to develop a full graduate-level programme are likely to face resistance from senior management. It is perhaps for this reason that relatively few participants have gone down this route.

The lack of enthusiasm for full MSc programmes, however, does not signal a reluctance to develop stand-alone courses in nuclear security. For example, some participants intend to develop short modules that will sit within already established MSc programmes. This option is attractive as it does not bring the challenges of developing a full MSc, yet allows the educator a good amount of scope to design a detailed course focused on student learning outcomes.

Universities are also increasingly serving as professional development hubs, providing opportunities for practitioners (industry, government, etc.) to gain additional knowledge and expertise in key areas of their profession. This route is typically less resource intensive and, indeed, can serve as a means of income generation for the university. In the nuclear security context, there is certainly an opportunity for academics to launch short courses aimed at professionals. This is

particularly the case in less explored areas of nuclear security, such as security culture, where there may exist little if any expertise within industry itself.

Whatever the approach, it is clear that success depends on internal support. Participants were unanimous in claiming that the successful integration of nuclear security into their education and training efforts requires high-level institutional support. In particular, it was noted that the prestige associated with international collaboration and recognition could offset many of the pressures associated with income generation and resourcing. As one participant noted: 'My university is very pleased that I am representing my department at international conferences and workshops on nuclear security. My superiors are happy that I am developing relationships with colleagues in other countries. This can lead to collaboration on research issues and maybe training workshops'.

Towards a Nuclear Security Community of Practice

Clearly, the themes set out above hold great relevance in terms of Wenger's three characteristics: mutual engagement, a joint enterprise; and a shared repertoire of resources. These are further explored below in the context of participant engagement with the PDC process and other relevant forums.

Mutual Engagement

One of the core drivers of the PDC process was to create an environment that facilitated peer-to-peer engagement around the theme of nuclear security. Sessions were designed to incorporate small-group work and joint assignments, with members free to self-select whom to work with when developing curricula and associated teaching resources. With participants drawn from all over the world and operating in different professional contexts, these engagements were marked by a host of different insights into both the challenges (bureaucratic, financial etc.) and opportunities for nuclear security education efforts. Experienced academics served as sounding boards for more junior colleagues, providing new ideas, sources of information and suggestions. Within the group, informal roles were quickly established including leaders, discussants and presenters. These roles were relatively amorphous in nature and evolved over the course of the process; as relationships developed, for example, participants with less experience gained confidence and began taking on more prominent roles during group work sessions and as part of joint assignments. Significantly, PDC instructors played a relatively minor role in shaping these expressions of mutual engagement. The parameters of the groups work sessions were outlined, as were the terms of the joint assignments; beyond this, however, the evolution of relationships within the participant groups was very much an organic process.

On a larger scale, the mutual engagement facilitated by group work and joint assignments spread beyond the immediate confines of the PDC process, with relationships being sustained beyond the close of the course. Collaboration in this regard has manifested itself in different ways, with certain participants continuing the

mutual development of teaching resources begun during the PDC, while others have provided direct lecturing support to fledging nuclear security courses launched at other institutions. The most ambitious plans involve the collaborative development of new nuclear security workshops catering for academic colleagues and industry practitioners in a specific region. For example, in January 2015, three former PDC participants from different organisations carried out a week-long nuclear security course for scientists and engineers in Nigeria. This grew out of their mutual engagement through the PDC process, which also served to directly shape the course content and approach. Here teaching materials and exercises originally delivered as part of the PDCs were adapted and refined to fit the Nigerian context, with the course also emphasising the importance of informal interaction through small group work. Similar workshops have also been run by small groups of former PDC participants in Ghana, Egypt and Morocco.

The PDCs have also served as vehicle through which to engage with the emergent global nuclear security education community more broadly. In this regard, the PDC process forms part of a symbiotic relationship with INSEN. The majority of PDC participants have now joined INSEN, swelling the community of emerging experts and infusing the organization with new enthusiasm, ideas and vigour. For its part, INSEN has provided these new members with a forum where members can work together to collaboratively develop teaching materials and undertake further professional development. The benefits of accessing a larger, formally structured international community of experts sharing similar interests and aspirations are considerable.

A Joint Enterprise

Given the considerable academic experience brought together through the PDC process it is no surprise that participants sought to actively shape how this process, including their peer-to-peer engagement, could best support their professional needs. Participants clearly highlighted their desire to explore the interaction of substantive knowledge and teaching, how curriculum design concepts apply to nuclear security and how these could be implemented within different organisational setups. Here, participant observation revealed that the pedagogically-focused sessions incorporated in the PDC schedules inevitably served to spark broader discussions on innovation and best teaching practices between colleagues from different organizations and countries. These acted as a force multiplier for the more structured teaching methods sessions. At stake here was a form of informal learning as participants developed collegial relationships that encouraged the transfer of knowledge that is often ‘difficult or impossible to codify and is tightly associated with a professional’s personal identity’, such as the lessons learned through experience (Snyder and Wenger, 2010, 110).

In order to accommodate this the PDC framework was kept deliberately flexible with considerable time allocated for discussion, which was free to evolve along whatever lines was deemed beneficial and important for the group.

Assignments goals were also up for debate and were negotiated between participants, with input from the instructors. These ranged widely from the development of specific teaching resources, such as table-top exercises or case studies, to curricula designed around specialized nuclear security topics. Once codified these served to shape the activities of the participants, who worked in small groups to develop resources for presentation back to, and critique from, the large cohort at the second week of the PDC. With these efforts in the longer term feeding directly into their own course development activities.

In parallel to the PDC process, the past two years has seen nuclear security education develop as a joint enterprise through the evolution of INSEN. While established by the IAEA with the ultimate goal of supporting nuclear security education internationally, the means by which this was to be achieved was deliberately left to its members. Drawing on their individual and collective experiences, INSEN members have developed different collaborative approaches to advancing nuclear security education, of which the PDC process is a component. These are codified in an INSEN Terms of Reference document, which was drafted and reviewed by members in the early stages of the organization's development. This has since served to inform activities and help socialize the objectives and approach of the Network to new members. INSEN members have also taken the lead in updating the key international guidance document for nuclear security education. Initially drafted by practitioners with a relatively narrow security-based training focus, INSEN members are working collaboratively to update this guidance to reflect a more academic and holistic approach to nuclear security. This guidance document will provide a key framework upon which educators can structure courses in this area. All of this work, as well as the cross-over and continuity between the PDC process and INSEN, suggests an ever-increasing coherence in the manner in which members of this international community of academics and experts identify with and are committed to advancing nuclear security education. On PDC participant summed up the situation well: 'Participation in INSEN is allowing me to continue the work that I started during the PDC […] This is important work. We have a responsibility to support the development of a strong nuclear security culture in countries around the world. Our way of doing this is through education'.

A Shared Repertoire

As participants engaged with one another, and the topic of nuclear security education, through the PDC process they adopted more formalized actions, concepts and means of communicating amongst peers. For example, having been exposed to different curriculum design concepts, many participants decided to adopt an approach based on constructive alignment. This served to shape their interactions and structure their thinking in this area as participants debated amongst themselves how best to link specific learning outcomes to different teaching and assessment methods. Participants also gradually adopted the technical language and terminology of nuclear security, as their understanding of different topics grew. This became a part of every day

communication in and around the PDCs. At the same time, this vocabulary served as an obstacle to be navigated by new participants and those unfamiliar with the subject-specific jargon. Recognising this challenge to engagement, PDC participants and others are working under the auspices of INSEN to develop a detailed glossary of terms of relevance to nuclear security education. Once finalized and distributed these will help clarify areas of misunderstanding and form the basis of a common technical language for PDC participants and INSEN members more broadly. This glossary will take its place in a growing body of member-generated resources that INSEN offers for free through its online platform. This body of resources constitutes a powerful repertoire designed to support the practice of academics seeking to engage with the subject.

Beyond these formal resources, the international character of each PDC group formed the basis of a dialogic context marked by diversity and the shared experiences of different national and cultural backgrounds. Presentations by and discussions among participants enabled the group to acquire new information, from anecdotes to administrative approaches, that could be contrasted with their own experience to create detail rich and engaging sessions on particular themes. At the least, this exchange highlighted for participants the breadth of diversity that the nuclear security education community encompasses. More than this, however, the process left a lasting impression on PDC participants. As one interviewee noted: 'I have learned about the experiences of my international colleagues. It is all interesting, from the challenges they face to the stories they tell, and it has opened my mind to many more issues regarding teaching nuclear security'.

Conclusion

In recent years, there has been a concerted international effort, embodied by the Nuclear Security Summit Series, to increase nuclear security around the globe. A significant part of this effort has focused on education and training, with the goal being to support the development of a robust nuclear security culture that will frame the work of nuclear professionals. The professional development 'train-the-trainer' approach has provided a unique vehicle for the pursuit of these objectives. The focus here has been on providing educators in relevant fields with the knowledge and expertise to integrate nuclear security into their professional practice. Crucially, the PDC model developed by King's College London has sought to blend substantive knowledge and understanding of key issues in nuclear security with teaching methods and pedagogical best practices. This approach is designed to equip educators with the means to engage students on nuclear issues and create a productive learning environment.

Empirical evidence gathered as part of an effort to gauge the impact of train-the-trainer PDCs reveals that this approach has been highly effective. Awareness and understanding of nuclear security and its value have been considerably heightened in all target countries, with PDC participants taking concrete steps to integrate nuclear security into their educational practice. On a larger scale, the process has contributed

to a broader international shift from a disparate, patchwork community of interest to a more structured community of practice in the area of nuclear security education. Educators who previously had little more than a personal interest in nuclear security and international developments in this field, have become members of an emergent community of academics and trainers with a comprehensive understanding of nuclear security, its multidisciplinary nature and the challenges associated with cultivating a strong security culture across the nuclear industry.

The PDC process has framed the development of new relationships (national and international) based on mutual engagement and a shared commitment to the nuclear security enterprise. Closely linked to this has been the emergence of a shared repertoire among PDC participants: more formalized actions, concepts and means of communication. The PDCs have also served as a force multiplier for other international initiatives seeking to encourage the coalescence of academics and industry practitioners around the theme of nuclear security. On the whole, then, the train-the-trainer PDC approach has made a substantial contribution to the development of a sustainable, international nuclear security education community, committed to infusing the next generation of nuclear experts with an understanding of nuclear security and its complexities.

Notes

[1] The International Atomic Energy Agency (IAEA) defines nuclear security as 'the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities' (IAEA, 2008, 3).

[2] Nuclear security culture is commonly defined as 'the assembly of characteristics, attitudes and behaviour of individuals, organizations and institutions which serves as a means to support and enhance nuclear security' (IAEA, 2008, 3).

[3] Examples of initiatives include the US State Department's Partnership for Nuclear Security (PNS), the UK Department of Environment and Climate Change (DECC) the International Atomic Energy Agency (IAEA), the World Institute for Nuclear Security (WINS) and the European Union Chemical Biological Radiological and Nuclear Risk Mitigation Centres of Excellence Initiative, among others.

[4] Unless otherwise stated, all quotations are taken from anonymised interviews or focus groups with PDC participants.

[5] The idea of an imagined community, developed by Benedict Anderson in the context of nationalism is a useful point of reference here (Anderson, 1983).

[6] This twin-pronged approach is significant since the majority of educators participating in the King's College London professional development courses, for example, have no formal qualifications or training in academic practice and/or teaching methods.

[7] Topics covered at the PDCs included external and internal threats, security culture and information security, nuclear regulation and nuclear materials management and forensics

[8] It should be noted that the research project received full ethical approval prior to commencement from the relevant ethics committee at King's College London.

[9] Countries represented in the study included Bangladesh, Bulgaria, Egypt, India, Indonesia, Jordan, Malaysia, Morocco, Nigeria, Pakistan, South Africa, Ukraine and Vietnam.

[10] The relevant question here asked how useful participants found the hypothetical facility as an educational tool (Scale of 1-5, 1=not useful, 5=very useful)

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